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THE NEXUS OF DIGITAL TRANSFORMATION AND GREEN INDUSTRY FOR SUSTAINABLE SUPPLY CHAINS: A CRITICAL SYSTEMATIC LITERATURE REVIEW

KETERKAITAN ERAT TRANSFORMASI DIGITAL DAN INDUSTRI HIJAU UNTUK RANTAI PASOK BERKELANJUTAN: SEBUAH TINJAUAN LITERATUR SISTEMATIS KRITIS

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ABSTRACT

Indonesia stands at a strategic juncture, simultaneously pursuing industrial modernization via the 'Making Indonesia 4.0' roadmap and committing to green economy principles. However, an evidence-based framework integrating these dual transformations within national supply chains remains absent. This study bridges this gap by synthesizing global literature on the digital-green nexus through a rigorous Systematic Literature Review (SLR) adhering to PRISMA guidelines, facilitated by the Rayyan platform. Thematic analysis of the selected corpus identified three core clusters: (1) digital technologies as critical enablers for circular economy practices; (2) synergies fostering sustainable business models; and (3) contextual implementation barriers. The primary contribution of this review is a novel conceptual framework that contextualizes global findings to provide actionable insights for Indonesian policymakers and industry leaders navigating the complexities of this twin transition.

Keywords: circular economy; digital transformation; green industry; sustainable supply chain.

ABSTRAK

Indonesia berada pada persimpangan strategis, secara bersamaan mengejar modernisasi industri melalui peta jalan 'Making Indonesia 4.0' dan berkomitmen pada prinsip-prinsip ekonomi hijau. Namun, kerangka kerja berbasis bukti yang mengintegrasikan kedua transformasi ini dalam rantai pasok nasional masih belum tersedia. Studi ini menjembatani kesenjangan tersebut dengan menyintesis literatur global mengenai keterkaitan digital-hijau (digital-green nexus) melalui Tinjauan Literatur Sistematis (SLR) yang ketat dan mematuhi pedoman PRISMA, serta difasilitasi oleh platform Rayyan. Analisis tematik terhadap korpus terpilih mengidentifikasi tiga klaster inti: (1) teknologi digital sebagai pemungkin kritis untuk praktik ekonomi sirkular; (2) sinergi yang mendorong model bisnis berkelanjutan; dan (3) hambatan implementasi kontekstual. Kontribusi utama dari tinjauan ini adalah kerangka konseptual baru yang mengontekstualisasikan temuan global untuk memberikan wawasan yang dapat ditindaklanjuti bagi para pembuat kebijakan dan pemimpin industri Indonesia dalam menavigasi kompleksitas transisi kembar ini.

Keywords: ekonomi sirkular; industri hijau; rantai pasok berkelanjutan; transformasi digital.

1. INTRODUCTION

1.1. The Indonesian Context: 'Making Indonesia 4.0' and the Green Industry Imperative

The global industrial landscape is undergoing a profound structural shift, defined by the concurrent imperatives of digital transformation and environmental sustainability—a paradigm increasingly termed the 'twin transition' [1].

For emerging economies, navigating this dual challenge is not merely an option but a strategic necessity for securing future competitiveness, resilience, and long-term socio-economic development [2]. Indonesia, as Southeast Asia's largest economy and a major global manufacturing hub, stands at the forefront of this complex transition.

The nation's strategic direction is currently underpinned by two cornerstone policies: the 'Making Indonesia 4.0' industrial modernization roadmap [3] and a national commitment to a Green Industry and Low-Carbon Development, in line with its Nationally Determined Contributions (NDCs) under the Paris Agreement [4].

To contextualize the urgency of this transition, a comparative analysis of key industrial and sustainability indicators is presented in Table 1. The data highlights that while Indonesia's industrial sector contributes significantly to its GDP, its logistics performance lags behind regional peers, identifying a critical area for improvement to enhance global competitiveness sustainably.

Table 1. Comparative Analysis of Industrial and Sustainability Indicators in Southeast Asia (2014–2024)

Indicator	Indonesia	Thailand	Vietnam

GDP Growth (annual %)	5.0%	3.5%	6.5%
Industry, value added (% GDP)	39.8%	42.1%	38.0%
Exports (% of GDP)	21.5%	65.3%	93.3%
LPI Score (1 to 5)	3.0	3.5	3.3
CO2 emissions (kt)	563,3	258,5	342,7

Source: World Bank [5]

The 'Making Indonesia 4.0' initiative aims to revitalize the manufacturing sector by leveraging disruptive digital technologies—such as the Internet of Things (IoT), Artificial Intelligence (AI), and Big Data analytics—to enhance productivity and global competitiveness [3].

Concurrently, the Green Industry imperative focuses on promoting resource efficiency, decarbonization, and Circular Economy (CE) principles to mitigate environmental degradation [2]. As depicted in Figure 1, these two powerful policy streams are not parallel but deeply intertwined. The successful implementation of a digitally advanced industrial ecosystem is inextricably linked to the achievement of sustainability goals. For instance, smart sensors can optimize energy consumption, while blockchain technology ensures the transparency of sustainable raw materials.

This intersection represents the critical nexus where Indonesia's future industrial sustainability will be determined.

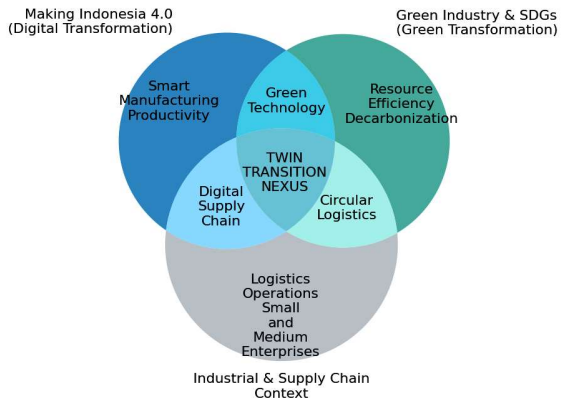

Figure 1. The Indonesian Policy Context: Intersecting 'Making Indonesia 4.0' and Green Industry Goals.

Source: Developed by the author based on [1], [3], and [4]

1.2. Problem Statement: Bridging Global Knowledge with Indonesian Industrial Reality

Despite clear strategic policy alignment, a significant gap exists between the conceptual ambition of an integrated digital-green transformation and its practical implementation within Indonesian supply chains. While global academic literature on the Industry 4.0 and sustainability nexus is expanding rapidly [6], [7], findings are predominantly derived from developed economies.

These studies often overlook the unique structural challenges faced by emerging economies like Indonesia, which include: (1) a highly fragmented industrial landscape dominated by Small and Medium-sized Enterprises (SMEs) with varying digital readiness; (2) significant disparities in infrastructure and digital connectivity across an archipelagic geography; and (3) **a** reliance on resource-intensive industries requiring context-specific decarbonization pathways.

Consequently, there is a distinct lack of a synthesized, evidence-based framework that translates global best practices on the digital-green nexus into actionable strategies for Indonesian policymakers and practitioners. The literature remains fragmented [6], and the Circular Economy concept, while a dominant global framework [8], requires significant contextual adaptation for effective implementation in Indonesia. This research addresses this critical problem by systematically reviewing and critically appraising the global body of knowledge to construct a framework that is both theoretically robust and practically relevant to Indonesia's industrial reality.

1.3. Research Questions and Objectives

This study is guided by the primary research question: *How can the global academic literature on the nexus of digital transformation and green industry be synthesized and contextualized to create an actionable framework for advancing sustainable supply chains in Indonesia?* To answer this, four sequential research objectives (ROs) were established:

RO1: To systematically identify, map, and synthesize dominant themes, theoretical foundations, and key findings from global literature on the digital-green nexus.

RO2: To critically appraise the methodological rigor and quality of the existing global evidence base.

RO3: To develop an integrated conceptual framework that adapts synthesized global knowledge to the specific drivers, barriers, and opportunities within the Indonesian industrial ecosystem.

RO4: To formulate a structured, policy-relevant future research agenda to support the implementation of the twin transition in Indonesia.

1.4. Scope and Contribution of the Study

The scope of this Systematic Literature Review (SLR) encompasses peer-reviewed journal articles published between 2014 and 2025, sourced from Scopus and Web of Science. While the evidence base is international, the analytical lens is explicitly focused on the Indonesian context.

This study makes three significant contributions. First, it provides a timely synthesis of global literature on the 'twin transition', a field that has seen exponential growth since 2021. Second, its primary theoretical contribution is a novel, integrated conceptual framework tailored for Indonesia (presented in Figure 5), bridging high-level policy ambitions with operational realities. Third, it offers a practical research agenda for Indonesian academics and evidence-based insights for policymakers at the Ministry of Industry (Kementerian Perindustrian) and the Ministry of National Development Planning (Bappenas).

1.5. Organization of the Paper

The remainder of this paper is structured as follows. Section 2 details the rigorous systematic literature review methodology. Section 3 presents the results of the review. Section 4 discusses these findings, interpreting them through an Indonesian lens and developing the integrated conceptual framework. Finally, Section 5 provides conclusions, outlines the structured future research agenda, and acknowledges study limitations.

2. METHODS

This section delineates the conceptual and methodological approach adopted in this study. It first details the multi-level theoretical framework that serves as the analytical lens, followed by the rigorous Systematic Literature Review (SLR) protocol employed for evidence synthesis.

2.1. Theoretical Foundations

To comprehensively analyze the intricate dynamics between industrialization, technology, governance, and sustainability, this study employs a hierarchical multi-level theoretical framework. At the macro level, the analysis is informed by the Grand Theory of Socio-Technical Systems, which posits that social and technical elements are deeply intertwined and co-evolve [9].

This perspective is crucial for understanding the twin transition not merely as a technological upgrade, but as a complex systemic shift involving actors, institutions, and technologies—a view particularly relevant to the large-scale industrial transformation envisioned in Indonesia [1].

To explicate firm-level behavior and policy influence within this systemic context, we draw upon two Middle-Range Theories. First, the Dynamic Capabilities View is utilized to analyze how firms "sense, seize, and reconfigure" resources to adapt to the twin transition, highlighting the necessity of developing both digital and green competencies—a critical challenge for Indonesian firms, particularly SMEs [10].

Second, Institutional Theory provides a lens to examine how external pressures from regulatory bodies (e.g., 'Making Indonesia 4.0' mandates), industry norms, and societal expectations (the "Pentahelix" stakeholders) shape corporate adoption of digital-green practices [11].

Finally, at the operational level, the analysis is grounded in the principles of an Applied Theory, the Circular Economy (CE). The CE serves as the primary operational framework for "green industry," offering concrete strategies (e.g., reduce, reuse, recycle) enabled by digitalization, as extensively documented in the literature [8], [12]. By integrating these theoretical tiers, this study transcends descriptive review to offer a conceptually rich, multi-dimensional analysis of the digital-green nexus.

2.2. Systematic Literature Review Protocol

This study employs a Systematic Literature Review (SLR) methodology to ensure a comprehensive, unbiased, and replicable synthesis of academic literature [13]. The review adheres to a pre-defined protocol structured into

three distinct stages: (1) identification, (2) screening, and (3) synthesis, following the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [14].

The initial identification stage targeted the global evidence base via two premier scholarly databases, Scopus and Web of Science (Core Collection). The search, executed in October 2025, covered the period from January 1, 2014, to October 31, 2025. To ensure precision, the search string integrated three conceptual pillars using Boolean operators:

Digital Concepts: "digital transformation," "digitalization," "Industry 4.0," "IoT," "blockchain," "big data."

Green Concepts: "green," "sustainability," "sustainable," "circular economy," "environmental."

Context: "supply chain," "logistics," "operations."

This systematic search yielded an initial total of 1,920 records. Subsequently, a multi-stage screening process was conducted to isolate the final corpus. The Rayyan web application was utilized to facilitate blinded screening and ensure collaborative decision-making. The PRISMA flow diagram in Figure 2 illustrates the attrition of articles at each stage.

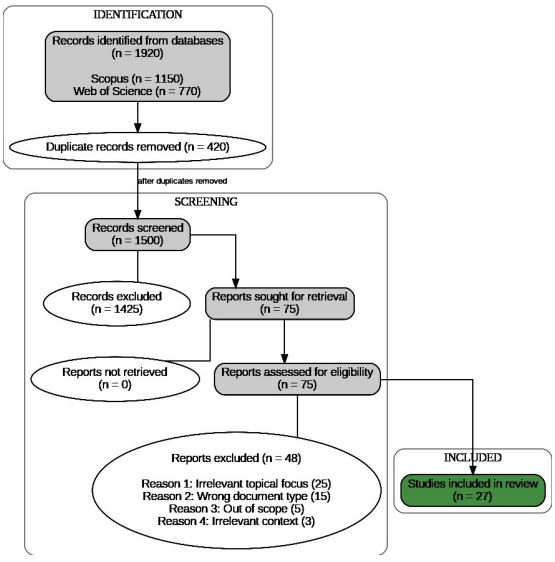
IDENTIFICATION
Records identified from databases (n = 1920)
Scopus (n = 1150)
Web of Science (n = 770)
Duplicate records removed (n = 420)
after duplicates removed
SCREENING
Records screened (n = 1500)
Records excluded (n = 1425)
Reports sought for retrieval (n = 75)
Reports not retrieved (n = 0)
Reports assessed for eligibility (n = 75)
Reports excluded (n = 48)
Reason 1: Irrelevant topical focus (25)
Reason 2: Wrong document type (15)
Reason 3: Out of scope (5)
Reason 4: Irrelevant context (3)
INCLUDED
Studies included in review (n = 27)

Figure 2. PRISMA 2020 Flow Diagram for the Systematic Study Selection Process.

Source: Adapted from Page et al. [14].

Selection was governed by strict inclusion and exclusion criteria, detailed in Table 2, ensuring only high-quality, peer-reviewed articles explicitly addressing the digital-green-supply chain nexus were retained.

Table 2. Inclusion and Exclusion Criteria for Article Selection

Criterion	Inclusion Criteria (IC)	Exclusion Criteria (EC)
Document Type	IC1: Peer-reviewed journal articles.	EC1: Grey literature, conference proceedings, book chapters.
Database	IC2: Indexed in Scopus or Web of Science.	EC2: Non-indexed sources.
Language	IC3: Published in English.	EC3: Non-English publications.
Period	IC4: Jan 1, 2014 – Oct 30, 2025.	EC4: Outside the timeframe.
Focus	IC5: Explicit nexus of Digital, Green, and Supply Chain.	EC5: Focus on single domain only.

Source: Developed by the author, based on [14]

Following the removal of duplicates and rigorous screening of titles, abstracts, and full texts, a final corpus of 27 articles was identified for in-depth analysis and thematic synthesis.

For the final stage, a structured data extraction form was used to capture key information from each of the 27 selected articles. A thematic synthesis was employed to code the findings and generate analytical "clusters." Throughout this process, a specific Indonesian analytical lens was applied. For the bibliometric analysis, VOSviewer software was used to generate keyword co-occurrence maps, a method validated in similar Circular Economy (CE) studies [15].

3. RESULTS AND DISCUSSION

This section elucidates the bibliometric profile of the selected literature and presents a critical thematic synthesis of the findings. Crucially, global evidence is interpreted through an Indonesian analytical lens,

culminating in the development of a contextualized conceptual framework.

3.1. Descriptive and Bibliometric Analysis

The descriptive analysis of the final corpus (N=27), detailed in Table 3, reveals a nascent yet rapidly consolidating research field. As illustrated in Figure 3, publication output has accelerated markedly, with over 80% of relevant articles published since 2021. This exponential growth underscores the topic's rising prominence in academic discourse, paralleling the intensifying global policy focus on the twin transition.

Methodologically, the field is currently dominated by literature reviews and conceptual studies (approx. 89%), indicating a phase of theoretical development rather than widespread empirical validation. Geographically, research is concentrated in Europe and Asia, with the manufacturing sector serving as the primary industrial context—a finding that aligns directly with the sectorial priorities of Indonesia's 'Making Indonesia 4.0' roadmap [3].

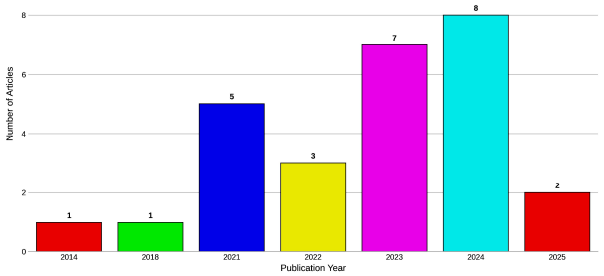

Figure 3. Annual Publication Trends of Global Literature on the Digital-Green Nexus (2014-2025).

Source: Authors' analysis of the N=27 reviewed articles.

Table 3. Descriptive Profile of the Reviewed Global Literature Corpus (N=27)

Category	Sub-Category	N	%
Methodology	Systematic/Bibliometric Review	17	63.0%
	Narrative Review	3	11.1%
	Conceptual/Framework	4	14.8%
	Empirical (Case/Survey)	3	11.1%
Leading Journals	Journal of Cleaner Production	15	55.6%
	Sustainable Prod. & Consump.	3	11.1%
	Heliyon	2	7.4%
	Others (1 article each)	*7*	*25.9%*
Industry Focus	Manufacturing (General)	10	37.0%
	General / Not Sector-Specific	8	29.6%
	Construction	2	7.4%
	Agri-food	2	7.4%
	Others (Textile, Glass, etc.)	*5*	*18.6%*

Source: Authors' analysis of the reviewed articles (N=27).

To map the intellectual structure of the field, keyword co-occurrence analysis was performed using VOSviewer (Figure 4). The network map identifies "circular economy" as the central node, exhibiting strong linkages to "sustainability," "digital transformation," and "digitalization." This centrality confirms the Circular Economy as the dominant theoretical and practical vehicle for operationalizing green industry principles within the digital era.

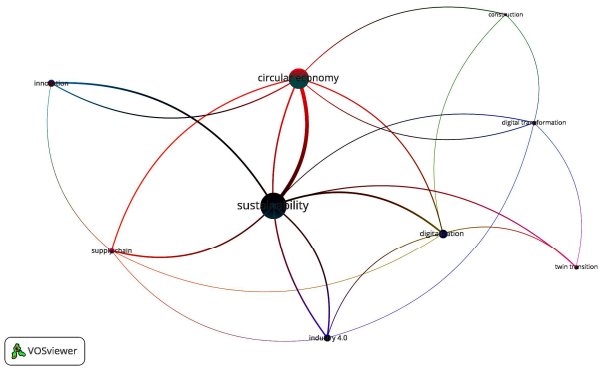

Figure 4. Bibliometric Map of Keyword Co-occurrence Network in Global Literature (N=27).

Source: Author's analysis using VOSviewer based on the final corpus (N=27).

3.2. Thematic Synthesis and Contextual Discussion

The global synthesis resonates strongly with challenges documented in the Indonesian context. For instance, Setiawan [11] identifies policy fragmentation and low technological adoption as barriers, advocating for Pentahelix collaboration. Our review extends this by positing digital transformation as the operational enabler for such collaboration. The thematic synthesis

distinguishes three core research clusters, summarized in Table 4.

Table 4. Thematic Synthesis of Key Research Clusters and their Relevance to Indonesia.

Cluster	Global Findings	Technologies	Contextual Relevance
1. Digital Enablers	Digitalization acts as an instrumental lever for resource efficiency.	IoT, AI, Blockchain [16], [17].	Supports 'Making Indonesia 4.0' goals; Blockchain is critical for export traceability.
2. CE Synergies	Enables "Smart CE" and novel business models (e.g., PSS).	Digital Platforms, PSS.	Opportunity for waste valorization; currently limited by archipelagic logistics costs.
3. Barriers	Success is mediated by contextual factors; high cost & skill gaps are major hurdles [10], [18].	N/A	Global barriers are amplified in Indonesia (specifically SME finance access & skill mismatches).

Source: Authors' synthesis based on the reviewed literature.

Cluster 1: Digital Technologies as Enablers for a Circular Economy

This cluster positions Industry 4.0 technologies as the backbone of the transition from linear to circular economies. As detailed in Table 5, specific tools offer distinct green utilities. IoT and sensors facilitate real-time resource monitoring [19], while AI optimizes complex reverse logistics [16]. Blockchain is pivotal for transparency [17], a feature increasingly demanded by Indonesia's export markets (e.g., palm oil, textiles) to verify sustainability claims.

Table 5. Key Industry 4.0 Enabling Technologies for a Circular Economy.

Technology	Application in CE	SDG Synergies
IoT & Sensors	Real-time monitoring; predictive maintenance.	SDG 9, 12
Big Data	Optimizing reverse logistics; demand prediction.	SDG 9, 7
Artificial Intelligence (AI)	Automated waste sorting; eco-design optimization.	SDG 11, 12
Blockchain	Traceability; verifying green claims and certifications.	SDG 12, 16
Additive Manufacturing (3D Printing)	On-demand production; spare parts creation to reduce inventory.	SDG 9, 12

Source: Adapted from Govindan [12] and Sánchez-García et al. [20].

Cluster 2: Synergies for Sustainable Business Models Digitalization catalyzes novel business models, shifting focus from product ownership to access (Product-Service Systems) [21].

For Indonesia, this offers a pathway to valorize waste streams. However, the archipelagic geography poses unique logistical challenges to the "Smart CE" model, particularly in establishing cost-effective reverse logistics networks essential for closing resource loops [22].

Cluster 3: Barriers, Capabilities, and Implementation Factors

The literature identifies high capital investment [18] and skill deficits [10] as universal barriers. In Indonesia, these are exacerbated by limited SME access to green financing [19] and a mismatch in vocational (SMK) curricula. Success relies not just on technology, but on "humanware"—developing the requisite digital-green competencies [23].

3.3. Integrated Framework and Projected Impact

Bridging the gap between global theory and local reality, this study proposes an Integrated Conceptual Framework

for Indonesia's Digital-Green Supply Chains (Figure 5). This framework explicitly links national policy drivers (Making Indonesia 4.0) to specific digital enablers and green practices, while accounting for the moderating effects of Indonesian-specific barriers (e.g., archipelagic logistics, SME dominance).

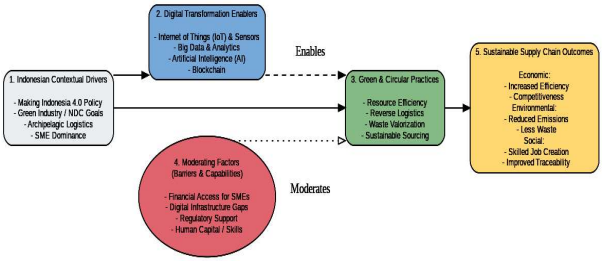

Figure 5. An Integrated Conceptual Framework for Indonesia's Digital-Green Supply Chains.

Source: Developed by the author based on literature synthesis.

The successful operationalization of this framework is projected to yield significant socio-economic benefits. As estimated in Table 6, a "decoupling" scenario is envisioned where industrial growth accelerates while emissions intensity stabilizes, thereby advancing national development goals without compromising environmental integrity.

Table 6. Projected 5-Year Impact of SDG-Aligned Industrialization on Indonesia (2025–2028)

Indicator	2025 (Base)	2026	2027	2028
GDP Growth (%)	5.0%	5.9%	6.1%	6.2%
Industry VA (% GDP)	39.8%	40.2%	40.6%	41.0%
LPI Score (1-5)	3.0	3.1	3.2	3.3
CO2 Emissions (kt)	563,3	575	585	590

Source: Authors' estimations based on World Bank data [5].

4. CONCLUSIONS

This systematic literature review has critically synthesized global evidence to bridge the knowledge gap regarding the digital-green nexus within the specific context of Indonesia's industrial transformation. By moving beyond generic analysis, this study provides a nuanced understanding of how digital transformation can serve as the linchpin for achieving a competitive, green industrial ecosystem in an emerging, archipelagic economy.

The review confirmed the existence of three robust thematic clusters: (1) digital technologies as critical enablers for circularity; (2) the synergy between digital and green initiatives in fostering sustainable business models; and (3) the persistent barriers mediating this transition. A critical finding is the scarcity of empirical evidence from emerging markets, highlighting the risks of uncritical policy transfer.

The primary theoretical contribution of this research is the development of the Integrated Conceptual Framework. This model moves beyond literature synthesis to operationalize global best practices for Indonesia, specifically addressing the constraints of archipelagic logistics and the centrality of SMEs.

4.1. Future Research Agenda

While this review establishes a foundational framework, its validation requires targeted empirical inquiry. Table 7 outlines a structured research agenda to guide future scholarship and policy formulation.

Table 7. A Structured Research Agenda for Advancing the Digital-Green Nexus in Indonesia.

Research Stream	Contextual Research Questions	Suggested Methods
1. Empirical Validation	What is the quantifiable ROI of digital-green investments in Indonesian firms?	Case studies; Longitudinal Survey.
2. SME Adoption Models	What are the unique barriers for Indonesian SMEs regarding the	Mixed-methods; Modified Technology Acceptance Model (TAM).

	twin transition?	
3. Policy & Governance	Which fiscal incentives effectively de-risk green investments for SMEs?	Comparative policy analysis; Stakeholder interviews.
4. Circular Logistics	How can digital tools optimize reverse logistics in an archipelagic setting?	Agent-based simulation modeling.

Source: Developed by the author based on identified literature gaps.

Pursuing these research streams will be critical for building a robust, localized body of knowledge to guide Indonesia's sustainable industrial future. This study calls for a collaborative effort among government, academia, and industry to translate these conceptual insights into tangible economic and environmental progress.

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APPENDIX

To uphold methodological transparency and facilitate replicability, the following appendices present the comprehensive data extraction matrix and the precise search algorithms employed in this systematic review.

Appendix A: Data Extraction and Synthesis Matrix of Selected Articles (N=27)

Study [Ref]	Methodology	Industry Context	Key Focus/Findings	Assigned Cluster*
Ayati et al. [18]	Systematic Review	General Supply Chain	Identifies barriers to circular supply chains, focusing on recovery approaches.	3. Barriers
Banihashemi et al. [24]	Review	Construction	Explores digital transformation enablers specifically for circularity in the construction sector.	1. Digital Enablers
Becerra et al. [25]	Review	Manufacturing	Reviews quantitative models for green supply chain inventory management.	2. Synergies

Beltrami et al. [6]	Conceptual	Manufacturing	Theorizes the relationship between Industry 4.0 and sustainability (Orchestration Theory).	2. Synergies
Bocken et al. [21]	Review / Conceptual	General Business	Develops archetypes for sustainable business models.	2. Synergies
Byers et al. [26]	Review	Construction	Technologies to address information gaps in building material reuse.	1. Digital Enablers
Delbari & Hof [27]	Empirical / Exp.	Glass Manufacturing	Using Industry 4.0/5.0 technologies for high-value glass waste recovery.	1. Digital Enablers
Doetsch & Huchzermeier [28]	Conceptual	General Supply Chain	Integrated framework for supply chain resilience and sustainability.	2. Synergies
El jaouhari et al. [29]	Review	General	Net-zero supply chain performance and Industry 4.0 technologies.	1. Digital Enablers
Gliedt et al. [30]	Empirical	General	Role of innovation intermediaries in accelerating sustainability transitions.	3. Barriers
Govindan [12]	Review / Conceptual	General Logistics	Transition from traditional to "Smart Circular Economy" via digitalization.	2. Synergies
Hartley et al. [31]	Conceptual	General	Circular economy as a response to global crises.	3. Barriers
Hermundsdottir & Aspelund [32]	Review	General	Link between sustainability innovations and firm competitiveness.	3. Barriers
Irajifar et al. [7]	Scientometric	General	Mapping the nexus between digitalization and sustainability.	1. Digital Enablers
Khan et al. [33]	Systematic Mapping	Manufacturing	Mapping I4.0, Triple Bottom Line, and Circular Economy.	2. Synergies
Khan, M. I. et al. [34]	Review	General	Pathways for integrating Industry 4.0 for enhanced sustainability.	1. Digital Enablers
Kirchherr et al. [8]	Content Analysis	General	Analysis of 221 definitions of Circular Economy.	3. Barriers
Kumar et al. [35]	Review	General Business	The role of finance as a driver/barrier for circular economy.	3. Barriers
Ma et al. [36]	Review	Energy-intensive Mfg.	Cleaner production and intelligent manufacturing in energy-intensive industries.	1. Digital Enablers
Mora-Contreras et al. [37]	Review	General Business	Effect of CE practices on corporate sustainability performance.	2. Synergies
Mouthaan et al. [1]	Scoping Review	General	Systemic sustainability effects of digitalization (positive & negative).	3. Barriers

Myshko et al. [38]	Review	Agri-food	Twin transition (digital + green) in the agri-food sector.	2. Synergies
Nilsson & Göransson [13]	Systematic Review	Supply Chain	Critical factors (drivers/barriers) for sustainable supply chain innovations.	3. Barriers
Nyangchak [2]	Systematic Review	General Industry	Emerging green industry toward net-zero economy.	2. Synergies
Raut et al. [16]	Critical Review	General	Application of AI specifically in Circular Economy contexts.	1. Digital Enablers
Rejeb et al. [17]	Systematic Review	General Supply Chain	Role of Blockchain in transitioning toward Circular Economy.	1. Digital Enablers
Rejeb et al. [19]	Systematic Review	General	IoT and Circular Economy: Research agenda.	1. Digital Enablers
Trevisan et al. [10]	Systematic Review	Manufacturing	Skills and competencies required for the twin transition.	3. Barriers

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